Atatürk Üniv Diş Hek Fak Derg (*J Dent Fac Atatürk Uni*)
Cilt:31, Sayı:4, Yıl: 2021, Sayfa: 522-7

Araştırma/ Research Article

EFFECT OF DIFFERENT SINGLE FILE SYSTEMS ON THE AMOUNT OF APICALLY EXTRUDED DEBRIS IN CURVED ROOT CANALS≠

FARKLI TEK EĞE SİSTEMLERİNİN EĞRİ KÖK KANALLARINDAN TAŞAN DEBRİS MİKTARINA ETKİSİ≠

Dr. Öğr. Üyesi Kübra YEŞİLDAL YETER* **Doç. Dr. Betül GÜNEŞ *** **Uzm. Dt. Emine Zeynep BAL***

Makale Kodu/Article code: 4942
Makale Gönderilme tarihi: 29.03.2021
Kabul Tarihi: 18.08.2021
DOI : *10.17567/ataunidfd.998438*

Kübra Yeşildal Yeter: *ORCID ID:* 0000-0002-7450-4119
Betül Güneş: *ORCID ID:* 0000-0001-7070-3033
Emine Zeynep Bal: *ORCID ID:* 0000-0002-3746-4920

ABSTRACT

Aim: Apical extrusion of necrotic tissues to the periapical area may cause postoperative pain and flare-ups and provoke an acute inflammatory response. The purpose of this study was to evaluate the apical debris extrusion after preparing root canals with different single-file Ni-Ti systems.
Material and Methods:A total of 45 extracted mandibular molar teeth were selected and the mesial root canals of the specimens were used for this study. The specimens were randomly divided into three groups (n = 15).
Group 1: Glide-path preparation was performed using OneG file and the root canals were instrumented with HyFlex EDM (Colténe/Whaledent).
Group 2: The root canals were prepared with OneCurve (Micro-Mega) file after creating a glide-path with OneG.
Group 3: OneG was used for glide-path preparation before preparing root canals with WaveOne-Gold primary file (Dentsply Maillefer).
The root canals were irrigated with 8 ml NaOCl during the preparation procedure. Apically extruded debris and irrigation solution during instrumentation was collected into pre-weighed Eppendorf tubes. The tubes were then stored in an incubator at 68 °C for 5 days for the evaporation of irrigation solution. The amount of extruded debris was calculated by subtracting the pre-instrumentation weight from the post-instrumentation weight of the Eppendorf tubes. The obtained data were analyzed using Kruskal-Wallis Test.
Results: The amount of extruded debris was not statistically different among the tested groups (P > 0.05). All tested files caused the extrusion of debris.
Conclusion: Under the conditions of this in-vitro study, there was no statistically significant difference among the HyFlex EDM, One-Curve and WaveOne-Gold primary files used with different kinematics and had different thermal treatments. All different single Ni-Ti file systems were associated with apical extrusion of debris.
Keywords: Apical Debris extrusion, dental instruments, endodontics, HyFlex EDM, OneCurve, root canal preparation, WaveOne-Gold,

ÖZ

Amaç: Nekrotik dokuların periapikal bölgeye taşması post-operatif ağrı ve provoke akut enflamatuar yanıta neden olabilir. Bu çalışmanın amacı kök kanallarının farklı Ni-Ti (Nikel-Titanyum) eğe sistemleri ile şekillendirilmesi sonrasında apikal bölgeye taşan debris miktarını karşılaştırmaktır.
Gereç ve Yöntem: Bu çalışma için toplam 45 adet mandibular molar diş seçilmiş ve örneklerin mezial kök kanalları kullanılmıştır. Örnekler rastgele üç gruba ayrılmıştır (n=15).
Group 1: Kanal içerisinde OneG eğesi ile rehber yol hazırlandıktan sonra, şekillendirme işlemi HyFlex EDM OneFile ile yapılmıştır.
Group 2: OneG eğesi ile rehber yol hazırlandıktan sonra kök kanalları OneCurve eğesi ile genişletilmiştir.
Group 3: Kök kanalları OneG eğesi ile rehber yol hazırlandıktan sonra WaveOne-Gold primary eğesi ile şekillendirilmiştir.
Şekillendirme sırasında kök kanalları 8ml NaOCl solüsyonu ile yıkanmıştır. Apikalden taşan debris ve irrigasyon solüsyonu ağırlığı önceden ölçülmüş olan Ependorf tüplerinde biriktirilmiştir. Tüpler daha sonra irrigasyon solüsyonunun buharlaşması için inkübatörde 68C°'de 5 gün boyunca bekletilmiştir. Apikalden taşan debris miktarı şekillendirme sonrası tartılan Ependorf tüplerinin ağırlığından şekillendirme öncesi ağırlıkları çıkartılarak hesaplanmıştır. Elde edilen veriler istatistiksel olarak Kruskal-Wallis testi ile değerlendirilmiştir.
Bulgular: Deneysel gruplar arasından apikalden taşan debris açısından istatistiksel olarak fark bulunmamıştır (P > 0.05). Bütün gruplarda apikal debris çıkışı gözlenmiştir.
Sonuç: *Bu in-vitro* çalışmanın koşulları altında farklı kinematiğe sahip ve farklı ısıl işlemler uygulanan HyFlex EDM, One-Curve ve WaveOne-Gold primary eğeleri arasında anlamlı bir fark bulunmamıştır. Bütün Ni-Ti eğe sistemleri apikalden debris taşmasına sebep olmuştur.
Anahtar Kelimeler: Apikal debris çıkışı, Endodonti, HyFlex EDM, kök kanalını hazırlama, OneCurve, WaveOne-Gold
maksilla

*Eskisehir Osmangazi University, Faculty of Dentistry, Department of Endodontics, Eskişehir
≠This study was presented at 4th International Medicine and Health Sciences Researches Congress as an oral presentation.

Kaynakça Bilgisi: Yeşildal Yeter K, Güneş B, Bal ZE. Farklı tek eğe sistemlerinin eğri kök kanallarından taşan debris miktarına etkisi. Atatürk Üniv Diş Hek Fak Derg 2021; 31: 522-7.
Citation Information: *Yesildal Yeter K, Gunes B, Bal ZE. Effect of different single file systems on the amount of apically extruded debris in curved root canals. J Dent Fac Atatürk Uni 2021; 31: 522-7.*

INTRODUCTION

Proper chemo-mechanical preparation of root canal system positively affects the success of endodontic treatment[1] Mechanical preparation of root canals allows not only the removal of necrotic and vital pulp tissues but also creates a space to perform disinfection using irrigation solutions and medicaments.[2,3] During chemo-mechanical root canal preparation, dentin chips, irrigation solutions, microorganisms and their by-products and pulp tissue remnants may extrude into the periradicular tissues.[4,5] The extrusion of these irritating factors may cause postoperative-pain or delayed periapical healing.[6,7] All instrumentation techniques and endodontic files cause the apical extrusion of debris.[4] There are several factors such as file kinematics and design, glide-path preparation, apical enlargement size, working length, and number of instruments that affect the amount of apically extruded debris.[3-5,8-10]

Nickel-titanium (NiTi) instruments were introduced to enable the optimal root canal preparation in a shorter time and with fewer procedural errors.[3,11] Mechanical and thermal treatments were applied to NiTi files to improve the torsional fracture and cyclic fatigue resistance of these systems. Several NiTi files with different kinematics were developed to complete root canal preparation more rapidly and in a simpler and safer way.[9,12] Single file systems with reciprocating and continuous rotation motion were manufactured for effective mechanical root canal debridement and quicker preparation.

The WaveOne Gold (WOG) single file reciprocating system (Dentsply/Sirona, Ballaigues, Switzerland) is manufactured using gold thermal treatment and is available in four sizes: small (#20/.07), primary (#25/.07), medium (#35/.06), and large (#45/.05). Heat treatment and cooling after manufacturing the WaveOne Gold file give the instrument its gold color.[13] The parallelogram-shaped cross-section of the file improves cutting efficiency, decreases the contact area within the root canal and enhances debris removal.[14]

The Hyflex EDM OneFile (Coltene-Whaledent, Altstatten, Switzerland) single file system is manufactured with controlled-memory wire using an electrical discharge machining process (EDM).[15] The sparks that are generated during the EDM process melt and evaporate the top layer of the file's surface.[16] This process causes an increase in the fracture resistance and cutting efficiency of the file.[3] The file is used with continuous rotational motion at a speed of 400 rpm and with 2.5 N.cm torque. The cross-section of the file is quadratic at the tip, trapezoidal in the middle and almost triangular at the top of the file. The taper of the file is 0.08 in the initial 4 mm, decreasing to 0.04 towards the middle and coronal portion and the tip size is #25.[17]

The OneCurve (OC) (Micro-Mega, Besancon, France) single file system, which can be used with continuous rotational movement, has recently been was developed. The file is manufactured with C-Wire technology contains an initial electropolishing and a following heat treatment processes.[18] The cross-section of the OneCurve file is variable along the blade for better cutting efficiency and centering ability.[19] The file has high cyclic fatigue resistance with prebending ability thus maintaining the initial root canal anatomy.[11,19] The OneCurve file is used at a speed of 300 rpm with a torque of 2.5 N.cm according to the manufacturer's instructions. The taper of the file is 0.06 and tip size is #25.

The objective of this in-vitro study was to compare the efficiency of three NiTi single file systems with different heat treatments and kinematics on apical debris extrusion. The null hypothesis tested in this study was that there would be no difference in the quantity of apically extruded debris after root canal preparation with the WaveOne Gold, Hyflex EDM OneFile and OneCurve files.

MATERIALS AND METHODS

The protocol of this in-vitro study was approved by the Ethics Committee of Eskisehir Osmangazi University and it was conducted in accordance with the Declaration of Helsinki. Extracted human mandibular molar teeth were collected and stored in distilled water for this study. Hard and soft tissue remnants of the specimens were removed mechanically. Preoperative cone-beam computed tomographic images were obtained to evaluate the root canal curvature and the presence of two independent mesial root canals. Teeth with external or internal root resorption and root cracks or fractures were discarded. Schneider's method was used to evaluate the degree of canal curvature. Specimens with angles of root canal curvature ranging from 25° to 35° were included.[20] A total of 45 freshly extracted

human mandibular molar teeth with fully formed apices and curved mesial roots were selected for this study. The distal roots of the specimens were resected and the coronal part of the teeth was removed to obtain an 18 ± 1mm mesial root length. Access cavities were prepared using round and fissure diamond bars and a high-speed handpiece under water cooling. A size #08 K file (Diadent, Chongchong,Korea) was used in the root canal to determine the apicall patency and was inserted until the tip of the file was visible at the root apex. The working length was established as 1 mm less than this length.

Debris Collection Apparatus

Separate Eppendorf tubes were used for each tooth and they were pre-weighed three times using a microbalance with an accuracy of 10^{-5} g (Mettler-Toledo AG, Greifensee, Switzerland). The mean pre-weight of each tube was measured.

The debris that was apically extruded during root canal preparation was collected using the test apparatus described by Myers and Montgomery.[21] The pre-weighed Eppendorf tube was fitted onto a glass vial and a silicone rubber cap with a round hole was inserted into the mouth of the Eppendorf tube. The specimen was inserted through the silicone cap up to the cemento-enamel junction. A 27- gauge needle was also placed in the rubber cap to balance the external and internal pressures. The flasks were covered with rubber-dam sheet to prevent the operator from seeing the apically extruded debris and irrigation solution (Figure 1).

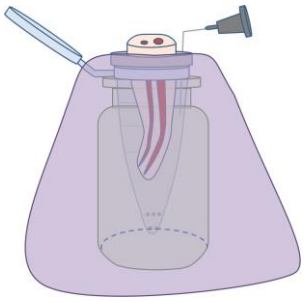

Figure 1. Schematic illustration of the experimental set-up.

Root Canal Preparation

The glide path was created using a One G instrument (Micro-Mega, Besancon, France) in all root canals and a total of 45 specimens were randomly divided into three experimental groups according to the root canal preparation instrument (n=15).

Group 1 (WOG): Root canals were instrumented using the WaveOne Gold single reciprocation file system.

Group 2 (HEDM): Root canal preparations were performed using the HyFlex EDM OneFile rotational system.

Group 3 (OC): Root canals were prepared with the OneCurve single rotational file system.

All instruments and glide path files were used with a torque controlled endodontic motor X-Smart Plus (Dentsply Maillefer, Ballaigues, Switzerland) according to the manufacturers' recommendations. Instruments were used with in-and-out movements until the file reached the working length, and the flutes of the files were cleaned after three pecking motions. Root canal preparations were performed by one operator. All root canals were irrigated with a total volume of 8 mL, 2.5% sodium hypochlorite (NaOCl) (Werax, Izmir, Turkey) solution. The needle was placed 2 mm short of the working length for the irrigation procedure. Apical patency was confirmed by using a #08 K-file after finishing the mechanical preparation. The specimens were removed from the experimental set-up after finishing the root canal preparation and the apical part of the root was washed with 1 mL distilled water to collect the debris adhering to the root surface.

Apically extruded debris and irrigation solution were collected in Eppendorf tubes. The tubes were removed from the experimental set-up after completing the root canal preparation and irrigation steps and placed into an incubator for 5 days (at 68 °C) to completely evaporate the irrigant and moisture. Eppendorf tubes with dry debris were weighed three times and the mean post-weight value was obtained for each tube. The amount of extruded debris was calculated by subtracting the pre-weight of Eppendorf tubes from the post-weight.

The statistical program SPSS 18.0 was used for the statistical analyses (SPPS Inc, Chicago, IL, USA) of mean amounts of debris extruded in the experimental groups. The level of statistical significance was set at $p < 0.05$. The obtained data were analyzed using the Kruskal-Wallis Test.

RESULTS

All tested files caused the extrusion of debris.

The amount of extruded debris did not differ significantly among the tested groups (P>0.05). The different instrumentation kinematics and heat-treatment of files had no effect on the apically extruded debris in root canals prepared with the WaveOne Gold, Hyflex EDM OneFile and OneCurve file systems. Statistical data belonging to the experimental groups was shown in Table 1.

Table 1. Mean± SE Mean, Minimum, maximum. Standard deviation, median and average rank values of experimental groups (g)

File system	n	Mean ± SE Mean	Minimum (g)	Maximum (g)	St. Dev	Median	Ave Rank
WaveOne Gold Primary	15	0,01816±0,00161	0,00932	0,02965	0,00622	0,01775	18,2
HyFlex EDM	15	0,01975±0,00113	0,01333	0,02982	0,00436	0,01824	21,6
One Curve	15	0,021717±0,00061	0,016820	0,025240	0,002395	0,022320	29,2

DISCUSSION

Post-operative pain, swelling and delayed healing might occur owing to the extrusion of debris into the periapical region during chemo-mechanical preparation of root canals.[22,23] Although there have been improvements to the methods used, all root canal shaping, irrigating and cleaning procedures cause the extrusion of intracanal contents into the periradicular region (24). This in-vitro study evaluated the amount of apically extruded debris in root canals instrumented with the WaveOne Gold, OneCurve and Hyflex EDM OneFile systems. According to the results of this study the amount of apically extruded debris did not differ statistically between experimental groups and all systems were associated with debris extrusion. Therefore, the null hypothesis of the study was accepted.

To the best of our knowledge there have been no studies comparing the effect of OneCurve, Hyflex EDM OneFile and WaveOne Gold single file systems on the extrusion of apical debris. Uslu et al. compared the amount of debris that apically extruded during endodontic instrumentation using Reciproc Blue, Hyflex EDM and XP-endo Shaper in mandibular premolars. The XP-endo Shaper group produced less debris than Reciproc Blue and the difference between the Hyflex EDM and other groups was not statistically significant (23). Elashiry et al. evaluated the amount of debris apically extruded from root canals prepared with the WaveOne Gold, Reciproc Blue and Hyflex EDM.[3] Contrary to our results they found that WaveOne Gold files caused less debris extrusion than HyFlex EDM files. The irrigation protocol and glide path preparation might explain the different results of these two studies.

Several studies have compared the effects of reciprocation or continuous rotation movement on apical debris extrusion. Some of these studies showed that reciprocation movements caused more debris extrusion than rotational movements.[4,23,25,26] On the other hand, others reported that the rotational motion was associated with more debris extrusion than reciprocation motion.[1,3,8,27] Also, similarly to our results no difference was found between continuous rotation and reciprocation movements with respect to apical debris extrusion.[26,28-30] The test designs, nickel-titanium instrument design and size, cross-section of the file, working length, apical preparation size, root canal anatomy and creating a glide path might be responsible for the different test results. In our study the glide path was created using One G NiTi rotary instruments in all groups and the amount of apically extruded debris did not differ significantly among the groups. Glide path preparation might be effective on the amount of apically extruded debris. Topcuoğlu et al. reported that, although OneShape showed less debris extrusion than the WaveOne and Reciproc single file systems without glide path preparation, no significant difference was observed between these single file systems when glide path preparation was performed before root canal instrumentation.[31]

NaOCl was used for irrigation in this study to simulate clinical conditions, as in other studies.[25,27,32] More dentinal debris was removed from the root canal walls after irrigation with NaOCl.[32] However the weight of debris was higher with NaOCl irrigation due to the crystallization of NaOCl solution after evaporation.[4,24] The position of the irrigation needle and the volume of irrigation solution should be standardized to minimize the effect of NaOCl crystallization.[25]

The method used to collect the apically extruded debris was based on the study by Myers and Montgomery.[21] In this in-vitro study natural pulp tissue and the physical back-pressure of periapical tissues were not simulated. The absence of periapical back-pressure might affect the amount of debris extruded.[33] Floral foam can be used to simulate periapical tissues but it might change the test results by absorbing the irrigation solution and debris.[4] The current results of this in-vitro study should be interpreted with a caution to clinical conditions. Also, it

should be considered that the experimental design was standardized for all specimens. Therefore, the results of this study might help clinicians to select of single file systems.

CONCLUSION

Under the limitations of this in-vitro study, all single file systems were associated with debris extrusion. The WaveOne Gold, Hyflex EDM OneFile and OneCurve systems with different kinematics and heat-treatments, showed similar debris extrusion values.

ACKNOWLEDGEMENTS
The authors would like to thank to Dr. Yasin Altay from the Eskisehir Osmangazi University Faculty of Agriculture for statistical analysis and Prof. Dr. Nafiz Oncu Can from, Anadolu University, Faculty of Pharmacy for microbalance support.
The authors deny any conflicts of interest/financial affiliation related to this study.

REFERENCES

1. Haridas K, Hariharan M, Singh P, Varughese A, Ravi AB, Varma KR. Effect of Instrumentation Techniques and Kinematics on Apical Extrusion of Debris: An In Vitro Study. J Contemp Dent Pract 2019;20:1067-70.
2. Hülsmann M, Peters OA, Dummer PMH. Mechanical preparation of root canals: shaping goals, techniques and means. Endodontic Topics 2005; 10: 30-76.
3. Elashiry MM, Saber SE, Elashry SH. Apical extrusion of debris after canal shaping with three single-file systems. Niger J Clin Pract 2020;23:79-83.
4. Burklein S, Schafer E. Apically extruded debris with reciprocating single-file and full-sequence rotary instrumentation systems. J Endod 2012;38:850-2.
5. Amaral AP, Limongi P, Fontana CE, Martin AS, Bueno C, Pinheiro SL. Debris Apically Extruded by Two Reciprocating Systems: A Comparative Quantitative Study. Eur J Dent 2019;13:625-8.
6. Seltzer S, Naidorf IJ. Flare-ups in endodontics: I. Etiological factors. J Endod 1985;11:472-8.
7. Silva EJ, Teixeira JM, Kudsi N, Sassone LM, Krebs RL, Coutinho-Filho TS. Influence of Apical Preparation Size and Working Length on Debris Extrusion. Braz Dent J 2016;27:28-31.
8. De-Deus G, Neves A, Silva EJ, Mendonca TA, Lourenco C, Calixto C, et al. Apically extruded dentin debris by reciprocating single-file and multi-file rotary system. Clin Oral Investig 2015;19:357-61.
9. Frota MMA, Bernardes RA, Vivan RR, Vivacqua-Gomes N, Duarte MAH, Vasconcelos BC. Debris extrusion and foraminal deformation produced by reciprocating instruments made of thermally treated NiTi wires. J Appl Oral Sci 2018;26:e20170215.
10. Gunes B, Yesildal Yeter K. Effects of Different Glide Path Files on Apical Debris Extrusion in Curved Root Canals. J Endod 2018;44:1191-4.
11. Razcha C, Zacharopoulos A, Anestis D, Mikrogeorgis G, Zacharakis G, Lyroudia K. Micro-Computed Tomographic Evaluation of Canal Transportation and Centering Ability of 4 Heat-Treated Nickel-Titanium Systems. J Endod 2020;46:675-81.
12. Yared G. Canal preparation using only one Ni-Ti rotary instrument: preliminary observations. Int Endod J 2008;41:339-44.
13. Elnaghy AM, Elsaka SE. Effect of sodium hypochlorite and saline on cyclic fatigue resistance of WaveOne Gold and Reciproc reciprocating instruments. Int Endod J 2017;50:991-8.
14. Webber J. Shaping canals with confidence: Wave One Gold single-file reciprocating system. Roots 2015;1:34-40.
15. Pirani C, Iacono F, Generali L, Sassatelli P, Nucci C, Lusvarghi L, et al. HyFlex EDM: superficial features, metallurgical analysis and fatigue resistance of innovative electro discharge machined NiTi rotary instruments. Int Endod J 2016;49:483-93.
16. Pedulla E, Lo Savio F, Boninelli S, Plotino G, Grande NM, La Rosa G, et al. Torsional and Cyclic Fatigue Resistance of a New Nickel-Titanium Instrument Manufactured by Electrical Discharge Machining. J Endod 2016;42:156-9.
17. Pinheiro SR, Alcalde MP, Vivacqua-Gomes N, Bramante CM, Vivan RR, Duarte MAH, et al. Evaluation of apical transportation and centring ability of five thermally treated NiTi rotary systems. Int Endod J 2018;51:705-13.
18. Staffoli S, Grande NM, Plotino G, Ozyurek T, Gundogar M, Fortunato L, et al. Influence of environmental temperature, heat-treatment and design on the cyclic fatigue resistance of three generations of a single-file nickel-titanium rotary

instrument. Odontology 2019;107:301-7.
19. Elnaghy AM, Elsaka SE. Cyclic Fatigue Resistance of One Curve, 2Shape, ProFile Vortex, Vortex Blue, and RaCe Nickel-Titanium Rotary Instruments in Single and Double Curvature Canals. J Endod 2018;44:1725-30.
20. Schneider SW. A comparison of canal preparations in straight and curved root canals. Oral Surg Oral Med Oral Pathol 1971;32:271-5.
21. Myers GL, Montgomery S. A comparison of weights of debris extruded apically by conventional filing and Canal Master techniques. J Endod 1991;17:275-9.
22. Ruiz-Hubard EE, Gutmann JL, Wagner MJ. A quantitative assessment of canal debris forced periapically during root canal instrumentation using two different techniques. J Endod 1987;13:554-8.
23. Uslu G, Ozyurek T, Yilmaz K, Gundogar M, Plotino G. Apically Extruded Debris during Root Canal Instrumentation with Reciproc Blue, HyFlex EDM, and XP-endo Shaper Nickel-titanium Files. J Endod 2018;44:856-9.
24. Tanalp J, Gungor T. Apical extrusion of debris: a literature review of an inherent occurrence during root canal treatment. Int Endod J 2014;47:211-21.
25. Nevares G, Xavier F, Gominho L, Cavalcanti F, Cassimiro M, Romeiro K, et al. Apical Extrusion of Debris Produced during Continuous Rotating and Reciprocating Motion. ScientificWorldJournal 2015;267264.
26. Toyoglu M, Altunbas D. Influence of Different Kinematics on Apical Extrusion of Irrigant and Debris during Canal Preparation Using K3XF Instruments. J Endod 2017;43:1565-8.
27. Silva EJ, Sa L, Belladonna FG, Neves AA, Accorsi-Mendonca T, Vieira VT, et al. Reciprocating versus rotary systems for root filling removal: assessment of the apically extruded material. J Endod 2014;40:2077-80.
28. Kocak S, Kocak MM, Saglam BC, Turker SA, Sagsen B, Er O. Apical extrusion of debris using self-adjusting file, reciprocating single-file, and 2 rotary instrumentation systems. J Endod 2013;39:1278-80.
29. Kucukyilmaz E, Savas S, Saygili G, Uysal B. Assessment of apically extruded debris and irrigant produced by different nickel-titanium instrument systems. Braz Oral Res 2015;29:1-6.
30. Aktemur Türker S, Uzunoğlu Özyürek E. Apİkalden Taşan Debrİs Mİktari Yönünden Üç Farkli Döner Eğe Sİstemİnİn Karşilaştirilmasi. Atatürk Üniversitesi Diş Hekimliği Fakültesi Dergisi 2015;25:185-8.
31. Topcuoglu HS, Duzgun S, Akpek F, Topcuoglu G, Akti A. Influence of a glide path on apical extrusion of debris during canal preparation using single-file systems in curved canals. Int Endod J 2016;49:599-603.
32. Farmakis ETR, Sotiropoulos GG, Abramovitz I, Solomonov M. Apical debris extrusion associated with oval shaped canals: a comparative study of WaveOne vs Self-Adjusting File. Clin Oral Invest 2016;20:2131-8.
33. Lu Y, Wang R, Zhang L, Li HL, Zheng QH, Zhou XD, et al. Apically extruded debris and irrigant with two Ni-Ti systems and hand files when removing root fillings: a laboratory study. Int Endod J 2013;46:1125-30.

Sorumlu Yazarın Yazışma Adresi
Kubra Yesildal Yeter
Eskisehir Osmangazi University, Faculty of Dentistry, Department of Endodontics, Eskişehir/Turkey
Phone: Business: +90505 2667501,
Fax: +90 222 239 1303
e-mail: kubrayesildal@gmail.com